EQ: What bases have you used today and how did they help you?

Agenda:

Visual introduction to Acid Base Chemistry

Objective:

You will see the product of an acid base rxn

Visual Introduction to acid base Chemistry

Part A:

Safety NaOH and HCl are corrosive, be cautious.

All waste down drain,

On piece of litmus paper (R and B) per table.

Heat with medium flame until water starts to boil

A visual Intro to Acid Base Chemistry" Part "B", and "C"

Part B

	Blue	Red	Broad
NH_3			
Laundry detergent			
Dish Washing Detergent			
Baking Soda			
Aspirin			
Buffered Aspirin			
Tap water			

Part C

Indicator	HCl color	NaOH color

A visual Intro to Acid Base Chemistry" Part "D"

Part D

	pH	w/ 0.05M HCl	w/ 0.05m NaOH
Solution A			
Solution B			
Solution C			
Solution D			

Agenda:

Complete one more section in the "Visual introduction to Acid-Base chemistry Lab"

Objective:

Following the lesson you will be able to distinguish simple acids and bases form each other and name them

Visual Introduction to Acid Base Chemistry

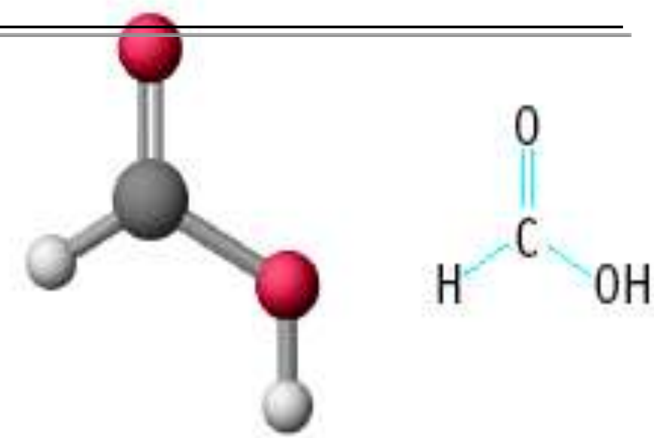
Part A:

NaOH (aq) + HCl (aq)→

$AgNO_3$ (ag) + →

Acid and Bases

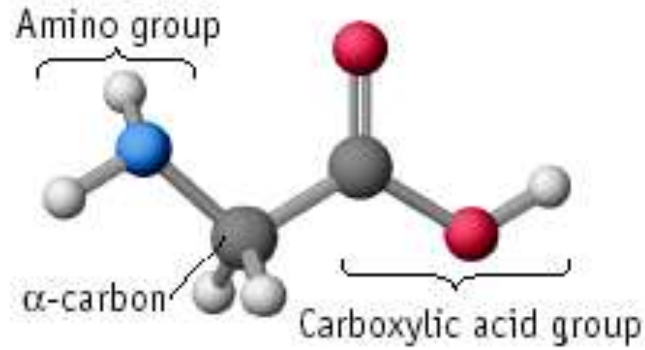
▲ The tartness of lemons and oranges comes from the weak acid citric acid. The acid is found widely in nature and in many consumer products. *(Charles D. Winters)*

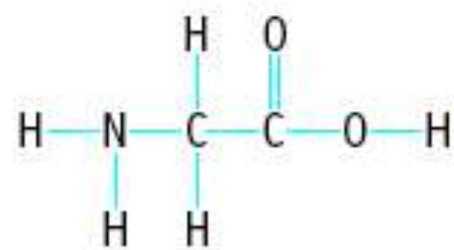


▲ The sting of ants is due to the weak acid formic acid, HCO_2H. *(Gallo Images/@ CORBIS)*

Acid and Bases

Aspirin is a weak acid that has been used as an analgesic for over 100 years. *(Charles D. Winters)*

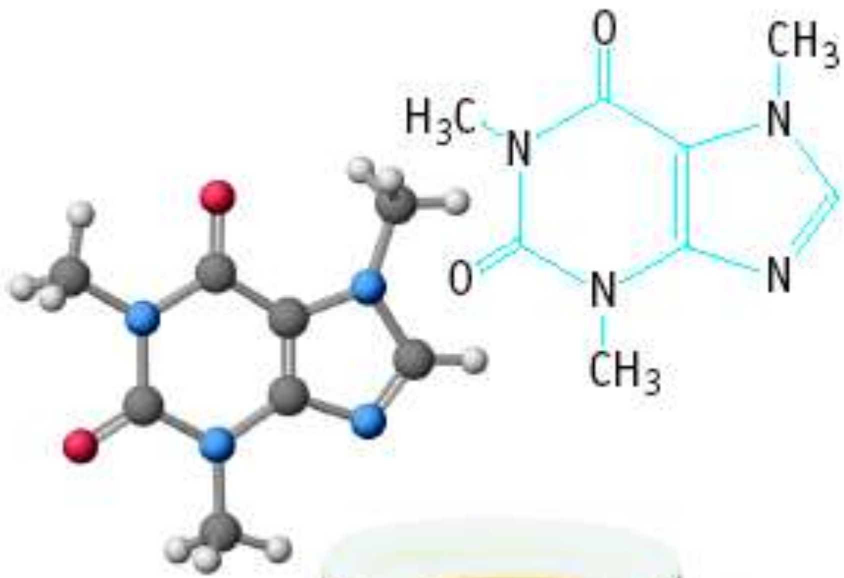




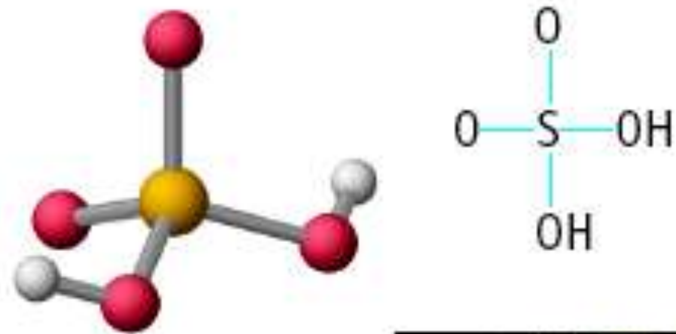
Glycine, $NH_2CH_2CO_2H$

Glycine is representative of the amino acids that are the basis of proteins. The $-CO_2H$ group is the acid portion of the molecule, and the $-NH_2$ group is the basic portion. *(Charles D. Winters)*

Acid and Bases



Caffeine is a well known stimulant and a weak base. *(Charles D. Winters)*



A sea slug excretes the strong acid sulfuric acid in self-defense. *(Sharksong/ M. Kazmers/Dembinski Photo Associates)*

Acids

Multiple definitions:

- **Lewis**
- **Arrhenius**
- **Bronsted Lowry**

Generally it's a chemical compound that produces a hydrogen ion concentration higher then pure water: [H^+] or [H_3O^+]

Acids

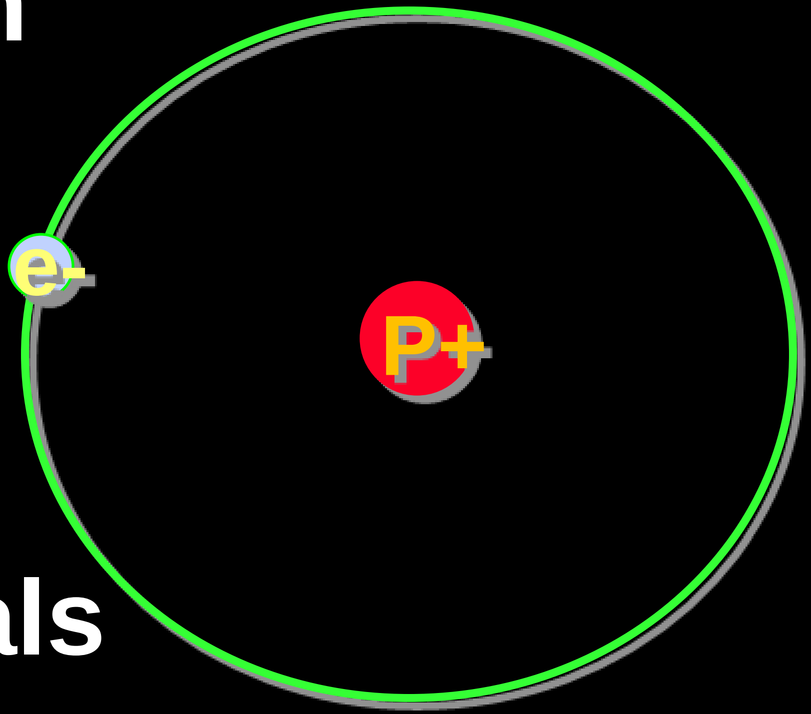
React with carbonates and bicarbonates to produce carbon dioxide gas

Have a sour taste. Vinegar is a solution of acetic acid. Citrus fruits contain citric acid.

Some Properties of Acids

Produce H^+ (as H_3O^+ ions in water):

Call a “proton”



Taste sour

Corrode metals

Acid Nomenclature Review

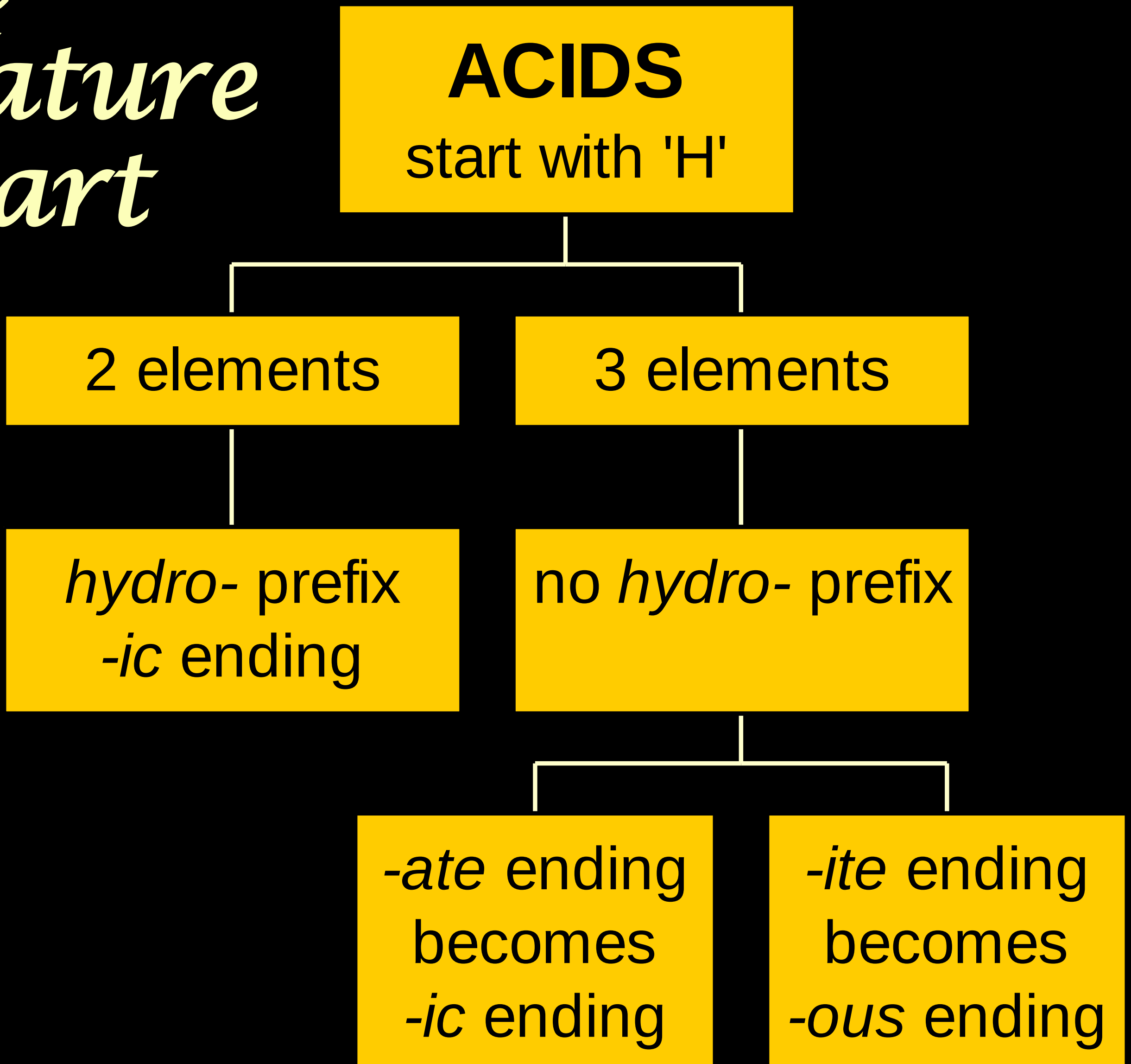
	Anion Ending	Acid Name
Binary →	*-ide*	*hydro-*(stem)*-ic acid*
Ternary	*-ate*	(stem)*-ic acid*
	-ite	(stem)*-ous acid*

Acid Nomenclature Review

An easy way to remember which goes with which…

"In the cafeteria, you ATE something ICky"

Acid Nomenclature Flowchart



Acid Nomenclature Review

$HBr_{(aq)}$ ⇒ **hydrobromic acid**

H_2CO_3 ⇒ **carbonic acid**

H_2SO_3 ⇒ **sulfurous acid**

Strong Acids

Completely dissociates in water.

You will need to remember these three:

HCl

H_2SO_4

HNO_3

Name 'Em!

HI

HCl

H_2SO_3

HNO_3

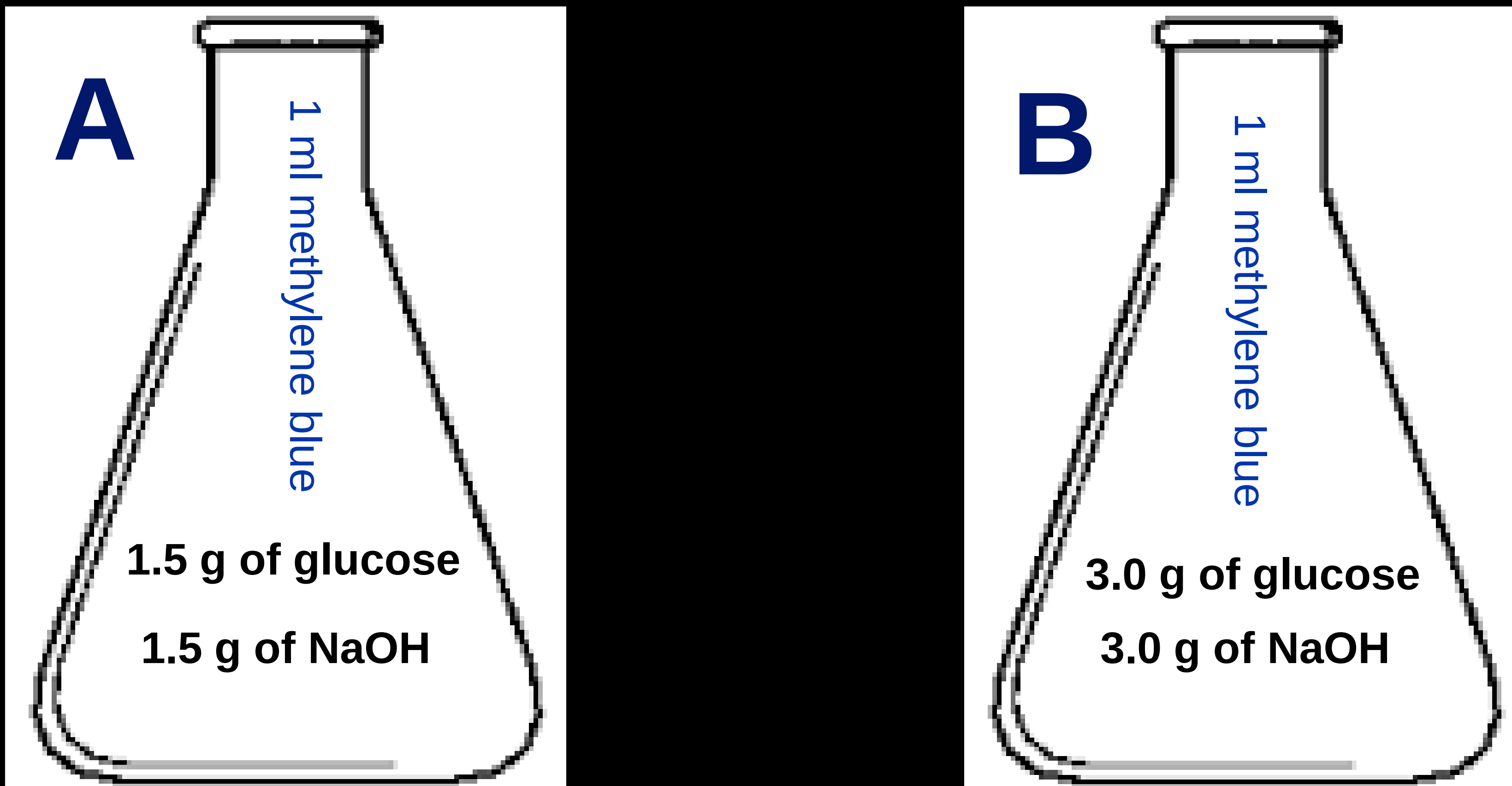
HIO_3

Which are strong acids?

Visual Introduction to Acid Base Chemistry

Complete one more section B, C, or D today

Color Change Oxidation



$$2CH_2OH–CHOH–CHOH–CHOH–CHOH–CHO + 1\ O_2 \rightarrow 2CH_2OH–CHOH–CHOH–CHOH–CHOH–COOH$$

Bases

A chemical species that donates hydroxide ions (OH^-) or that accepts protons.

Have a bitter taste.

Feel slippery. Many soaps contain bases.

Some Properties of Bases

Produce OH^- ions in water

Taste bitter, chalky

Are electrolytes

Feel soapy, slippery

Name these Common Bases

NaOH	Drain cleaner
KOH	Liquid soap
$Ba(OH)_2$	Stabilizer for plastics
$Mg(OH)_2$	Milk of magnesia
$Al(OH)_3$	Maalox (antacid)

Naming Bases

Group I metals all form strong bases with hydroxide

Same name as chemical name

Ex. NaOH – Sodium hydroxide

List the rest of them (write their names and chemical formulas)

KNOW THEM

Before you Can Go…

In your own words define:

- What an acid and base are,
- How can you distinguish them,
- How do you name them

Visual Introduction to Acid Base Chemistry

Complete one more section B, C, or D today

Agenda

Acid base definitions

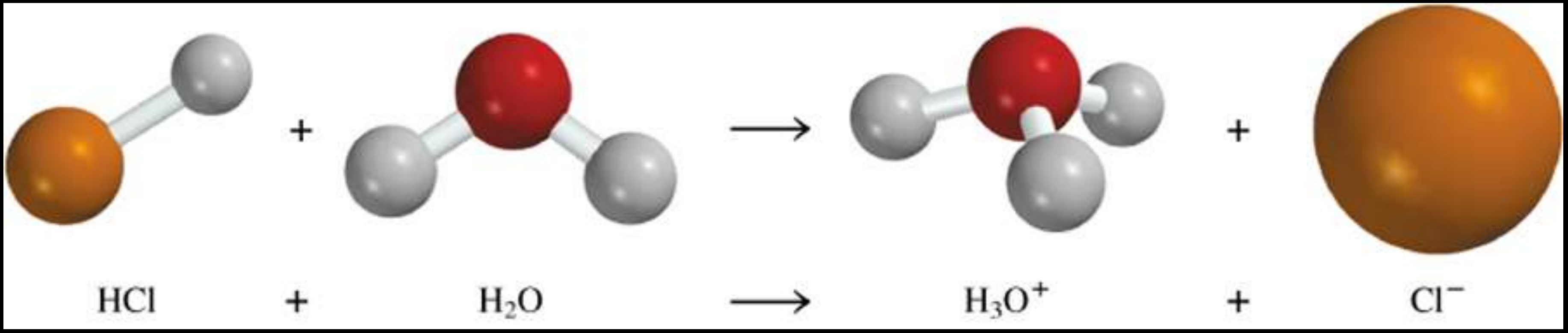
pH

pH → [H^+]

Objective:

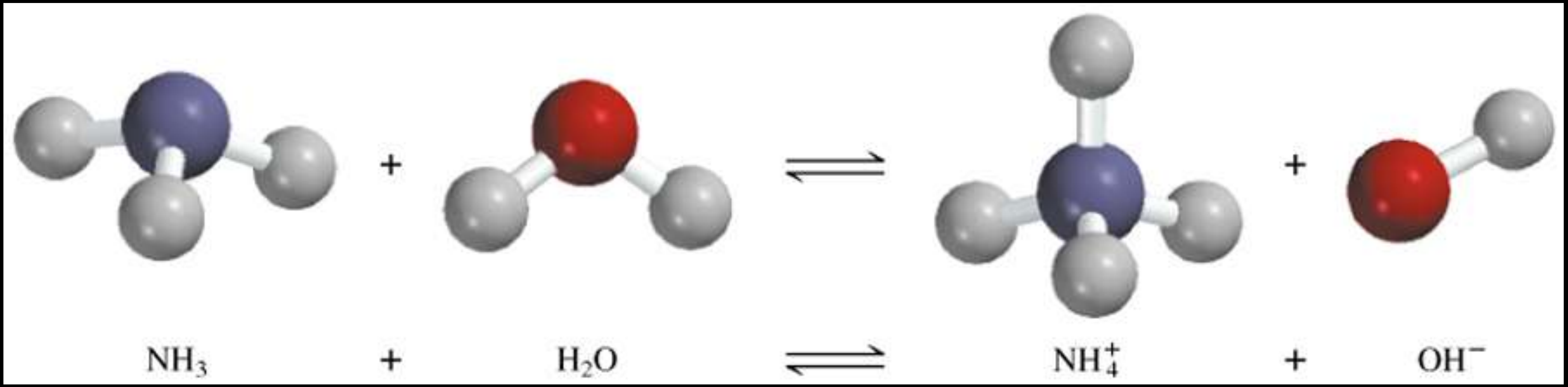
You will begin to see the connection between Arrhenius, Brønsted – Lowry, and Lewis acids/bases plus conjugate acids or bases. And start to look at calculating pH and [H^+]

Arrhenius acid: "is a substance that produces H^+ (H_3O^+) in water"



$$HCl + H_2O \rightarrow H_3O^+ + Cl^-$$

Arrhenius base: "is a substance that produces OH^- in water"



$$NH_3 + H_2O \rightarrow NH_4^+ + OH^-$$

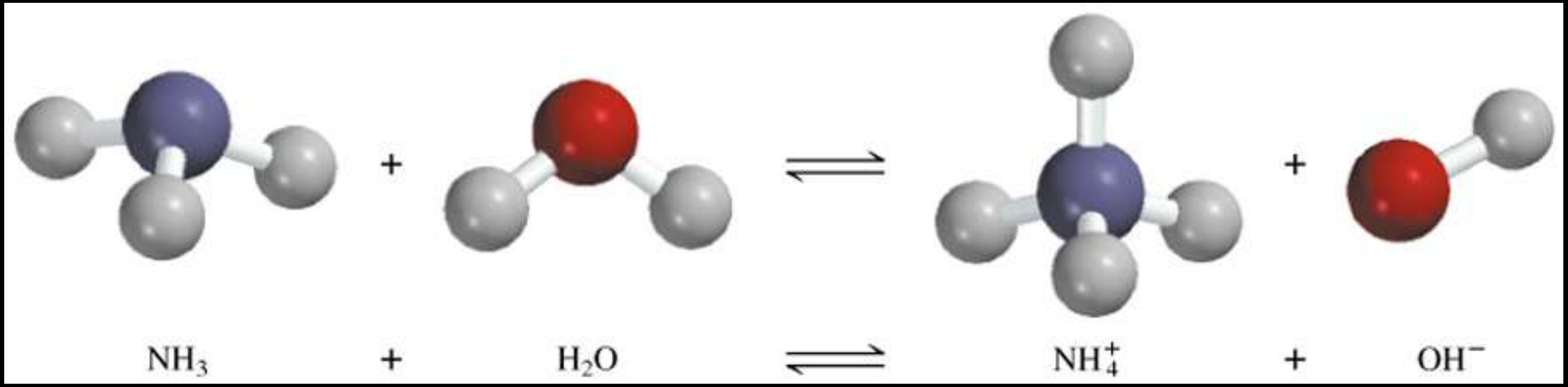
Acid/Base Definitions

Definition #2 Brønsted – Lowry

- **Acids – proton donor**
- **Bases – proton acceptor**
- **A "proton" is really just a hydrogen atom that has lost it's e^-!**

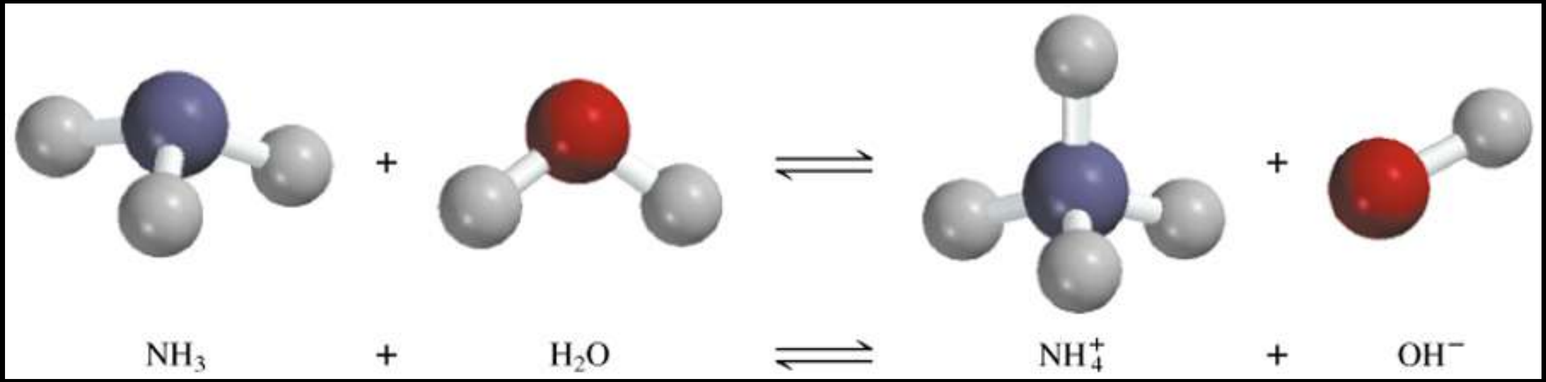
A Brønsted-Lowry acid is a proton donor

A Brønsted-Lowry base is a proton acceptor



$NH_3 + H_2O \rightarrow NH_4^+ + OH^-$

base **acid** **conjugate acid** **conjugate base**



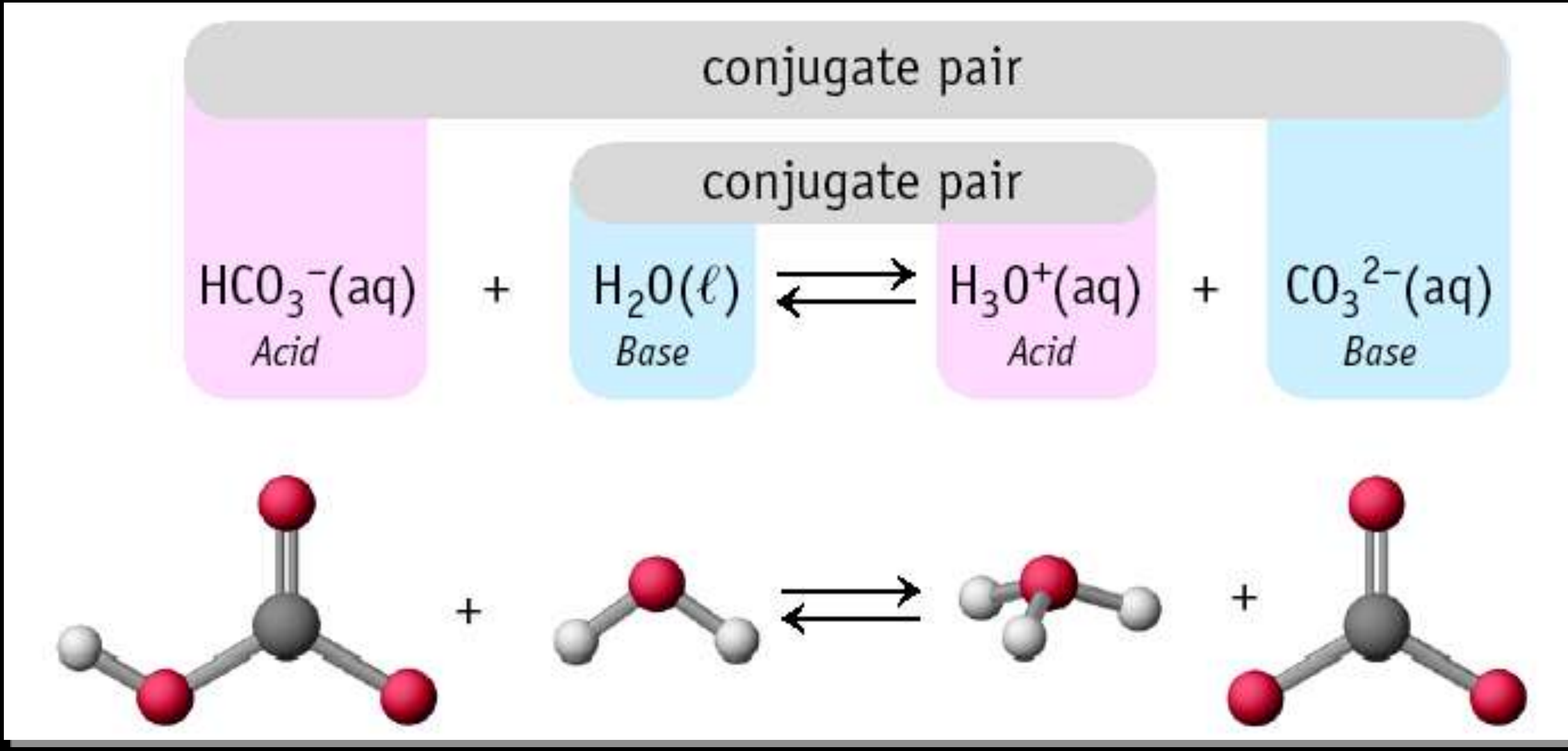
NH_3 + H_2O → NH_4^+ + OH^-

base | acid | conjugate acid | conjugate base

conjugate acid: substance formed when base gains a hydrogen ion

conjugate base: substance formed when an acid loses a hydrogen ion

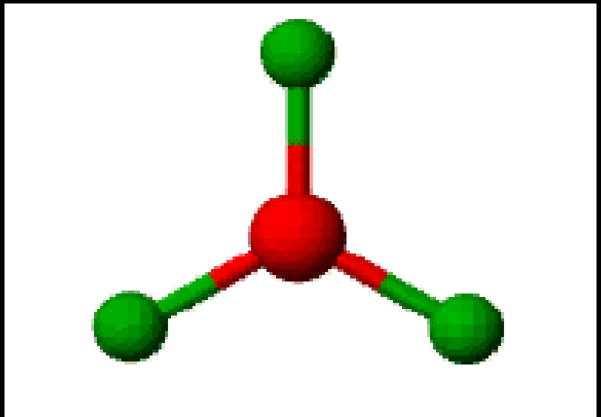
Conjugate Pairs



Acids & Base Definitions

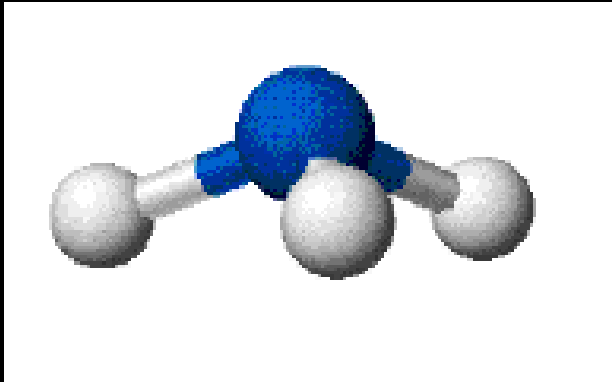
Definition #3: Lewis

Lewis acid - a substance that accepts an electron pair



BF_3, the boron atom is surrounded by only three electron pairs.

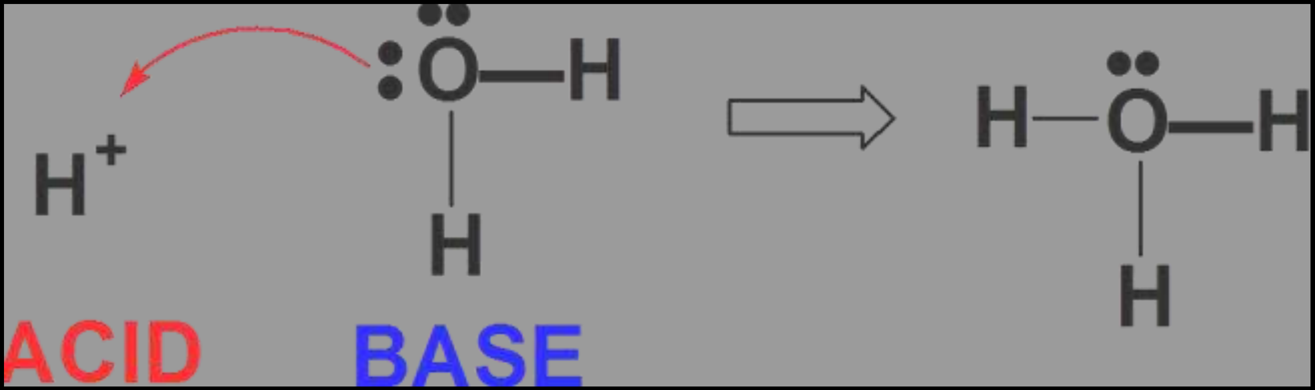
Lewis base - a substance that donates an electron pair



NH_3, the N atom has three bond pairs and one lone pair of electrons.

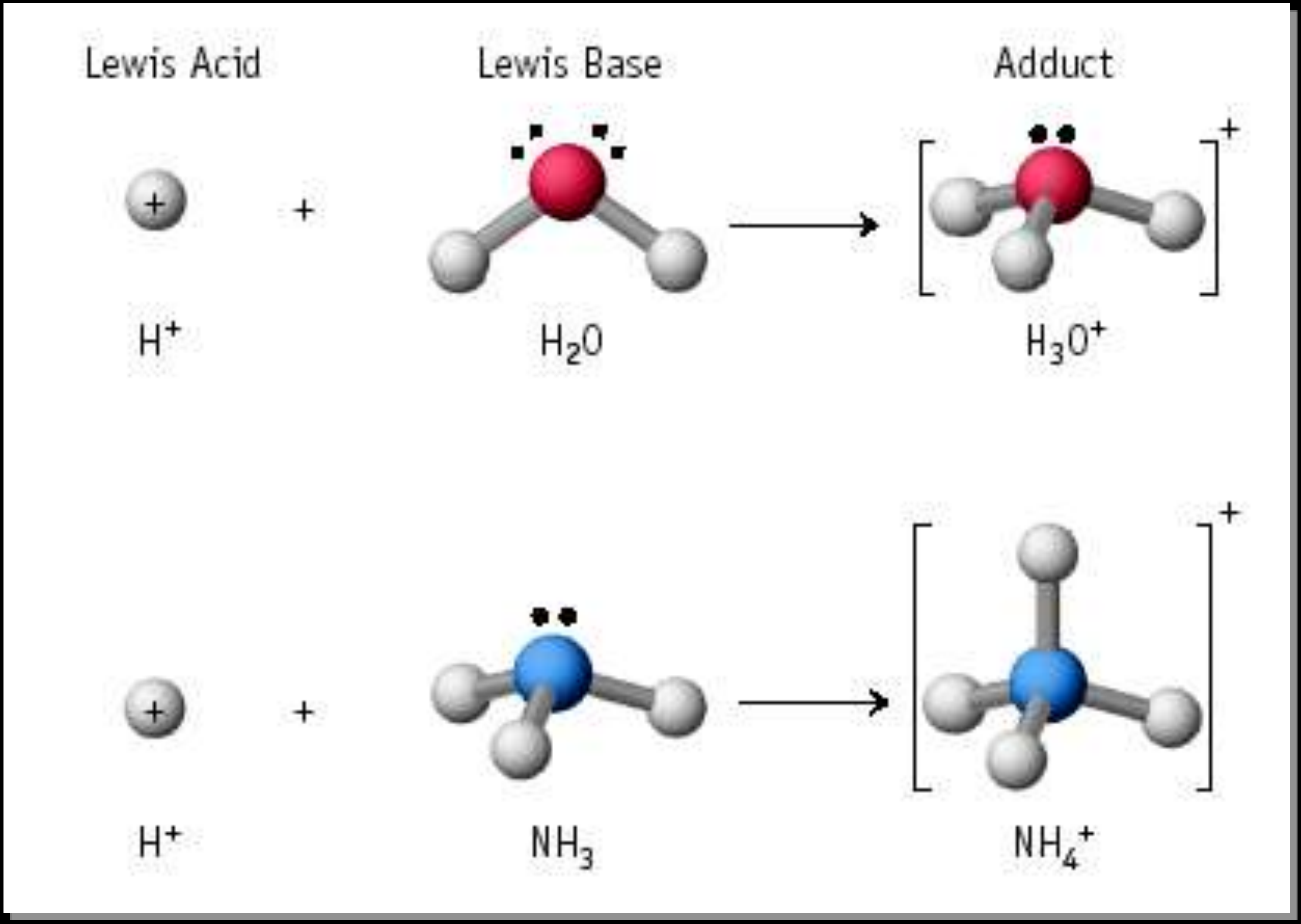
Lewis Acids & Bases

Formation of hydronium ion is also an excellent example.



Electron pair of the new O-H bond originates on the Lewis base.

Lewis Acid/Base Reaction



Learning Check!

Label the acid, base, conjugate acid, and conjugate base in each reaction:

$$HCl + OH^- \rightarrow Cl^- + H_2O$$

$$H_2O + H_2SO_4 \rightarrow HSO_4^- + H_3O^+$$

For most Acid Bases Rxns

The generic equation for most acid base rxn is:

$$HA + BOH \rightarrow BA + H_2O$$

You will get a salt and water out of an acid base rxn!

You try… write out the products:

$HA + BOH \rightarrow BA + H_2O$

You will get a salt and water out of an acid base rxn!

1) $HCl + NaOH \rightarrow NaCl + H_2O$

2) $HNO_3 + KOH \rightarrow KNO_3 + H_2O$

3) Tricky $HC_2H_3O_2 + NaOH \rightarrow$

$NaC_2H_3O_2 + H_2O$

Acetate ion

What volume of a 1.420 *M* NaOH solution is required to titrate 25.00 mL of a 4.50 *M* H_2SO_4 solution?

WRITE THE BALANCED CHEMICAL EQUATION!

$$H_2SO_4 + 2NaOH \longrightarrow 2H_2O + Na_2SO_4$$

volume acid → (*M* acid) → moles acid → (Mole Bridge) → moles base → (*M* base) → volume base

$$25.00\ \text{mL} \times \frac{4.50\ \text{mol}\ H_2SO_4}{1000\ \text{mL soln}} \times \frac{2\ \text{mol NaOH}}{1\ \text{mol}\ H_2SO_4} \times \frac{1000\ \text{ml soln}}{1.420\ \text{mol NaOH}} = 158\ \text{mL}$$

Recap!

Identify the acid, base, and conjugate acid and base in each equation:

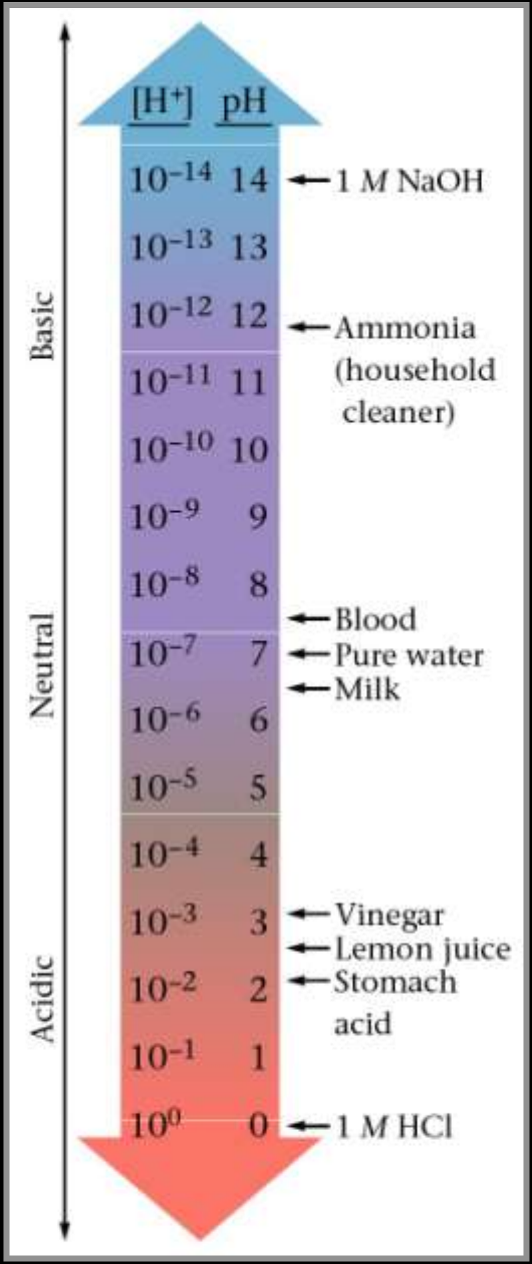
$$H_2SO_4 + H_2O \rightarrow HSO_4^- + H_3O^+$$

pH scale = way of expressing the strength of acids & bases. Instead of using very small #'s, we just use the NEGATIVE power of 10 on the Molarity of the H^+ (or OH^-) ion.

Under 7 = acid

7 = neutral

Over 7 = base



pH of Common Substances

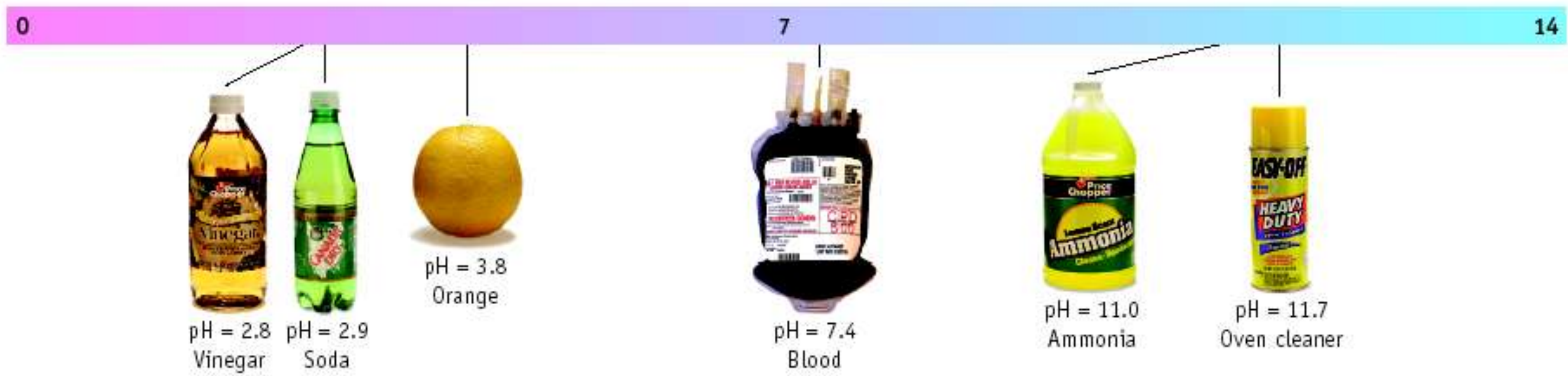


Figure 5.17 pH values of some common substances. Here the "bar" is colored red at one end and blue at the other. These are the colors of litmus paper, commonly used in the laboratory to decide if a solution is acidic (litmus is red) or basic (litmus is blue). *(Charles D. Winters)*

Calculating the pH

$pH = -\log [H^+]$

$pH = -\log [H_3O^+]$

(Remember that the [ ] mean Molarity)

Example: If $[H^+] = 1x10^{-10}$

$pH = -\log 1 \times 10^{-10}$

$pH = -(-10)$

$pH = 10$

For a strong acid [H+] ~ the molarity of the solution

Calculating the pH

pH = - log [H+]

(Remember that the [ ] mean Molarity)

Example: If $[H^+] = 1.8 \times 10^{-5}$

$pH = -\log 1.8 \times 10^{-5}$

$pH = -(-4.74)$

$pH = 4.74$

Try These!

Find the pH of these:

1) A 0.15 M solution of Hydrochloric acid

2) A 3.00 x10^{-7} M solution of Nitric acid

3) A 6.0M solution of Sulfuric acid

pH Cals. Solving for $[H^+]$

If the pH of Coke is 3.12, $[H^+]$ = ???

Because pH = - log $[H^+]$ then

- pH = log $[H^+]$

Take antilog (10^x) of both sides and get

$10^{-pH} = [H^+]$

$[H^+] = 10^{-3.12} = 7.6 \times 10^{-4}$ M

*** to find antilog on your calculator, look for "Shift" or "2^{nd} function" and then the "log" button

Agenda

pH recap

pOH

pH → $[H^+]$ → $[OH^-]$ → pOH Flow Chart

Titrations

Objective: You will be able to intervonvert between pH → $[H^+]$ → $[OH^-]$ → pOH.

pH Cals. Solving for H+

A solution has a pH of 8.5. What is the Molarity of hydrogen ions in the solution?

$pH = -\log [H^+]$

$8.5 = -\log [H^+]$

$-8.5 = \log [H^+]$

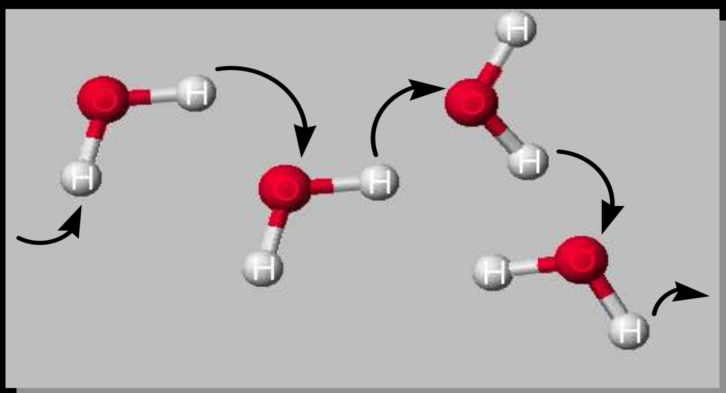
Antilog -8.5 = antilog $(\log [H^+])$

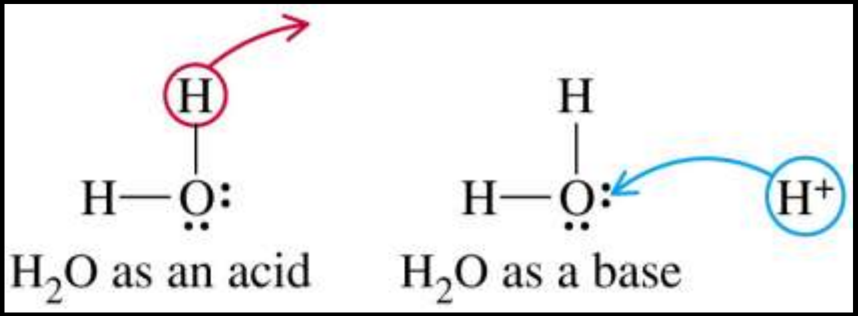
$10^{-8.5} = [H^+]$ → **3.16×10^{-9} M**

More About Water

H_2O can act as both an ACID & a BASE.

In pure water there can be **AUTOIONIZATION**





Equilibrium constant for water = K_w

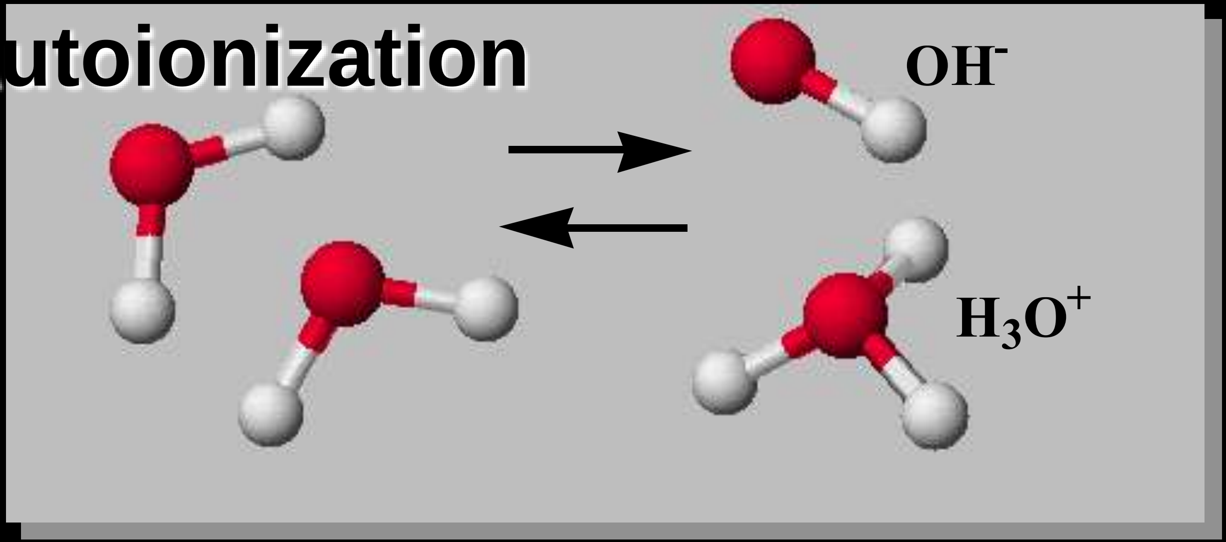
$$K_w = [H_3O^+][OH^-] =$$

$$K_w = [H^+][OH^-] =$$

1.00 x10^{-14} at 25 °C

More About Water

Autoionization



K_w = $[H_3O^+]$ $[OH^-]$ = 1.00 x 10^{-14} at 25 ^oC

In a **neutral** solution $[H_3O^+]$ = $[OH^-]$

so K_w = $[H_3O^+]^2$ = $[OH^-]^2$

and so $[H_3O^+]$ = $[OH^-]$ = 1.00 x 10^{-7} M

pOH

Since acids & bases are opposites, pH and pOH are opposites!

pOH does not really exist, but it is useful for changing bases to pH.

$$\underline{pOH = -\log [OH^-]}$$

Since pH and pOH are on opposite ends of scale,

$$pH + pOH = 14$$

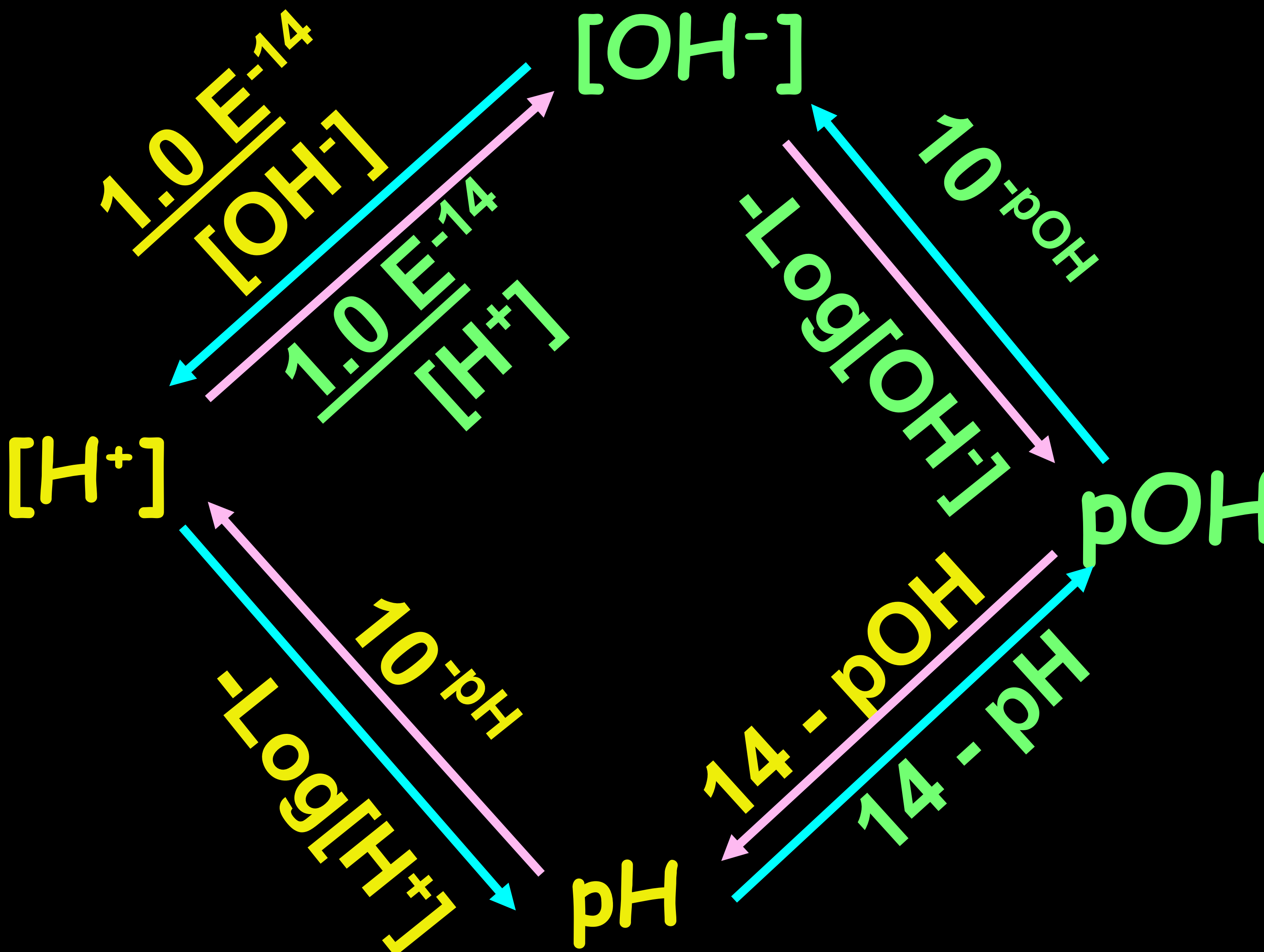
K_w

Water dissociation constant; K_w.

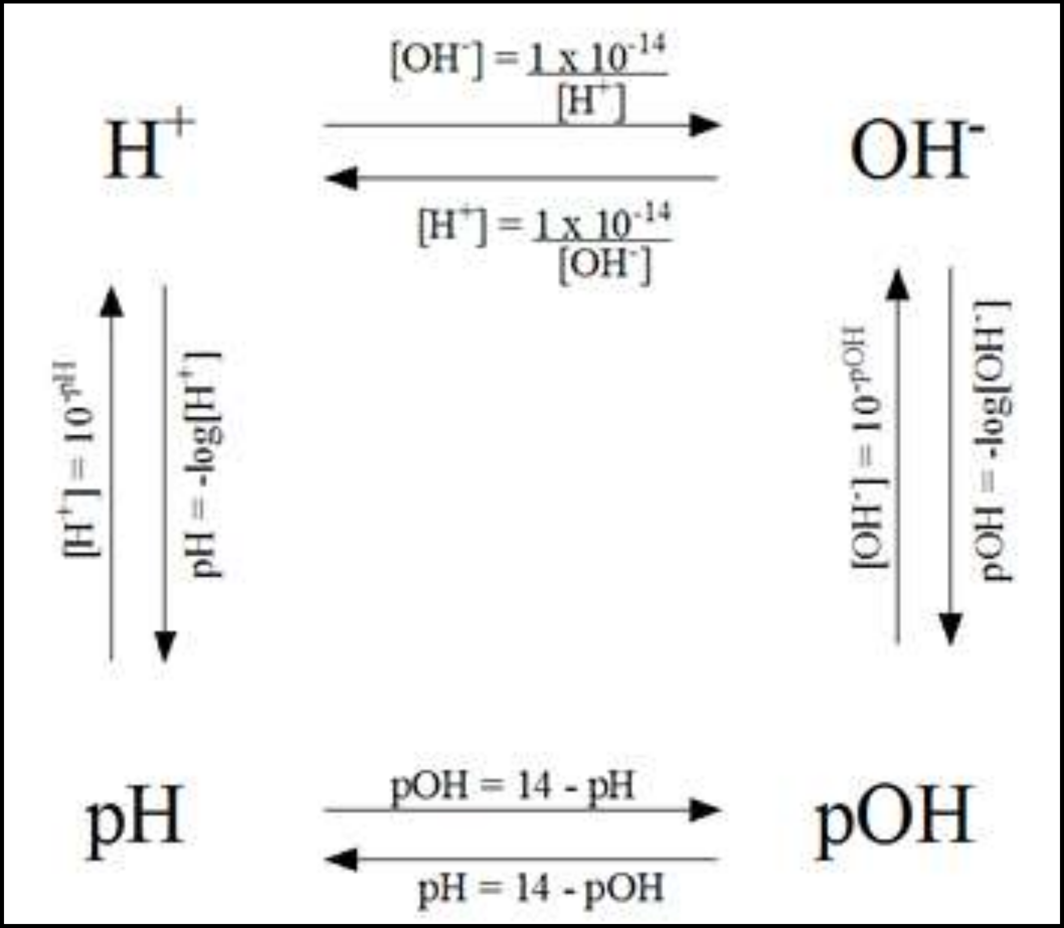
$K_w = 1.0\times10^{-14}$

$K_w=[H^+][OH^-]$

$1.0\times10^{-14} =[H^+][OH^-]$



[OH-]
[H+]
pH
pOH
1.0 E-14 / [OH-]
1.0 E-14 / [H+]
10-pOH
-Log[OH-]
10-pH
-Log[H+]
14 - pOH
14 - pH

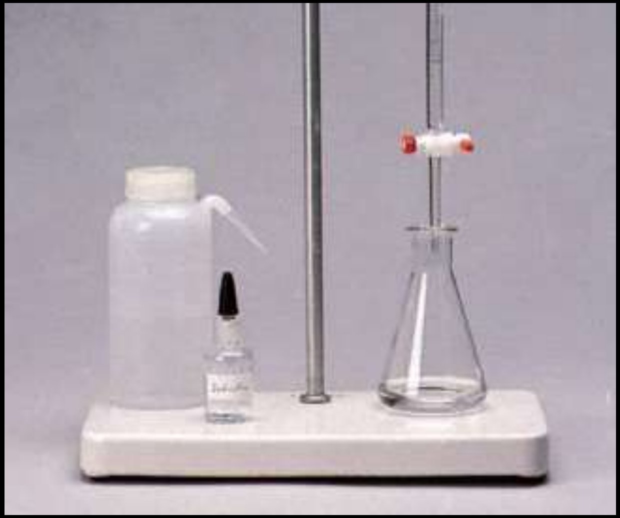

[OH⁻] = 1 x 10⁻¹⁴ / [H⁺]
H⁺
OH⁻
[H⁺] = 1 x 10⁻¹⁴ / [OH⁻]
[H⁺] = 10⁻ᵖᴴ
pH = -log[H⁺]
[OH⁻] = 10⁻ᵖᴼᴴ
pOH = -log[OH⁻]
pOH = 14 - pH
pH
pOH
pH = 14 - pOH

Titrations

In a *titration* a solution of accurately known concentration is added gradually added to another solution of unknown concentration until the chemical reaction between the two solutions is complete.

Equivalence point the point at which the reaction is complete

Indicator – substance that changes color at (or near) the equivalence point



Slowly add base to unknown acid UNTIL

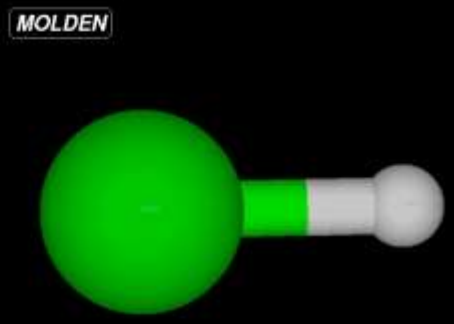
the indicator changes color

Acid Base Rxn Titration

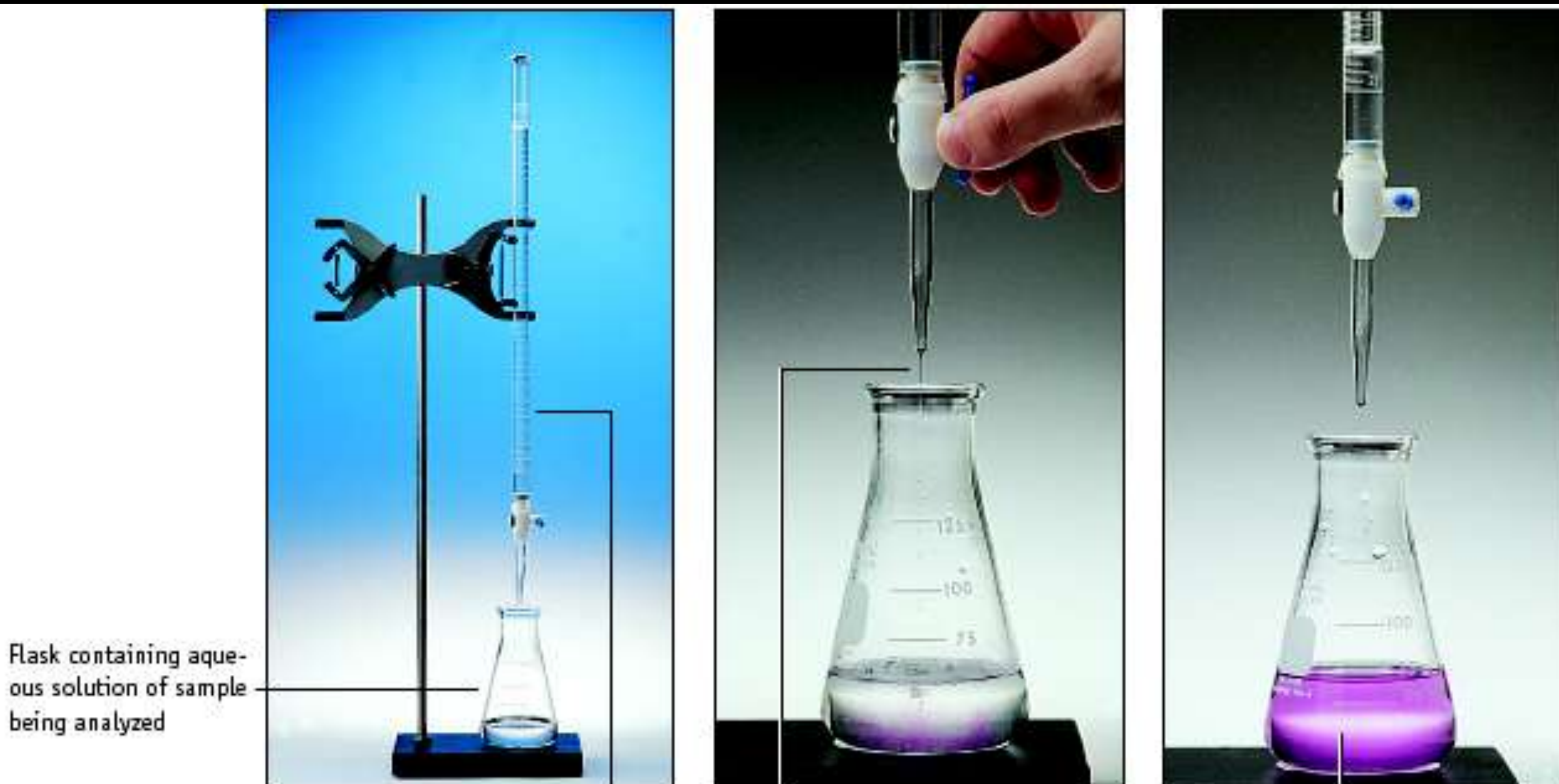
$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

acid **base**

Carry out this reaction using a TITRATION.



Setup for titrating an acid w/ a base



(a) 50-mL buret containing aqueous NaOH of accurately known concentration

(b) A solution of NaOH is added slowly to the sample being analyzed. The sample is mixed.

(c) When the amount of NaOH added from the buret exactly equals the amount of H^+ supplied by the acid being analyzed, the dye (indicator) changes color.

Bell Work
18/19-Mar-2014

When ammonia reacts with water an ammonium ion and hydroxide is produced.

-Write a balanced equations.

-What type of base is ammonia if it is producing hydroxide?

$[H_3O^+]$, $[OH^-]$ and pH

What is the pH of the 0.0010 M NaOH solution?

[OH-] = 0.0010 (or 1.0×10^{-3} M)

pOH = - log (0.0010)

pOH = 3

pH = 14 – 3 = 11

OR

$K_w = [H^+][OH^-]$

$[H^+] = 1.0 \times 10^{-11}$ M

pH = - log (1.0×10^{-11}) = 11.00

A man went into the doctor for testing, the tests revealed that he had a [OH^-] of 1.28×10^{-12}. What is the pH of his urine?

You Try ☺

The pH of rainwater collected in a certain region of the northeastern United States on a particular day was 4.82. What is the H^+ ion concentration of the rainwater?

You Try ☺

The OH^- ion concentration of a blood sample is 2.5×10^{-7} M. What is the pH of the blood?

Calculating [H^+], pH, [OH^-], and pOH

Problem 1: A chemist dilutes concentrated hydrochloric acid to make two solutions:

(a) 3.0 *M*

(b) 0.0024 *M*.

Calculate the [H^+], pH, [OH^-], and pOH of the two solutions at 25°C.

Calculating [H^+], pH, [OH^-], and pOH

Problem 2: What is the [H^+], [OH^-], and pOH of a solution with pH = 3.67? Is this an acid, base, or neutral?

Problem 3: What is molarity of a solution made from 4.5g of NaOH dissolved to a volume 450ml? If you furture diluted it to 800ml what would its new molarity be?

Acid Base Titration

Acid Base Titration Calculations

Recall our dilution formula

$$M_1V_1 = M_2V_2$$

M = Molarity (mol/L)

V = Volume (L)

Think of it like this:

$$M_{acid}V_{acid} = M_{base}V_{base}$$

Problem

What volume of 0.1M HNO_3 is need to completely neutralize 0.050L of 0.2 M NaOH?

What are we looking for?

What do we know

Lab example: Neutralization of NaOH by HCl

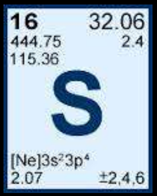
35.62 mL of NaOH is neutralized with 25.2 mL of 0.0998 M HCl by titration to an equivalence point. What is the concentration of the NaOH?

Intro To titration Lab

1. Add solution from the buret (base).
2. Reagent (base) reacts with compound (acid) in solution in the flask.
3. Indicator shows when exact stoichiometric reaction has occurred. [Acid] = [Base]

This is called NEUTRALIZATION

Bell Work



-April-2015

When 15mL of Nitric Acid is triturated with 21.5mL of 0.5M Potassium Hydroxide to neutralization:

1. Write a balanced equation ***and*** net ionic equation
2. What is the concentration of the nitric acid
3. What is the pH of the nitric acid?

$$M_{acid}V_{acid} = M_{base}V_{base}$$

Calculating $[H^+]$, pH, $[OH^-]$, and pOH

Problem 4:

What is the $[H^+]$, $[OH^-]$, and pOH of a solution with pH = 8.05? Is this an acid, base, or neutral?

Problem 5:

What is the $[H^+]$, $[OH^-]$, and pH of a solution with pOH = 12.05? Is this an acid, base, or neutral?

Calculating [H+], pH, [OH-], and pOH

Problem 6:

If 20ml of a 19.0M solution of NaOH is added to 2 480ml of water, what is the new molarity?

What is the *molality*?

What is the pH?

Agenda

Objective:

You will standardize a NaOH sample

Standardization Titration Lab

Two part lab:

Part I: Titration 1 find moalrity of NaOH

We will use a salt, KHP ($KHC_8H_4O_4$) to find the exact molarity of NaOH.

Once we know the molarity of the NaOH, we will…

Part II: Find molarity of unknown Apple Juice,

Again perform titrations to find the exact molarity of your unknown Apple Juice

Standardization Titration Lab

Two part lab:

Part I: Titration 1 find moalrity of NaOH

How many grams of KHP are you going to use?

What glassware will you use to make your KHP solution?

Bell Work
21-Mar-2014

What is the concentration of NaOH in a buret if it took 18.1mL to neutralize 0.620g of KHP? (C8H5KO4)

The Weak Acid / Base Rxn

Recall a balanced equation.

What is on the left side?

The right side?

When you compare the concentration (molarity, [mol/L]) of all reactants and to all products you get something called and <u>equilibrium expression</u>.

Where "K" is the equilibrium constant for that rxn

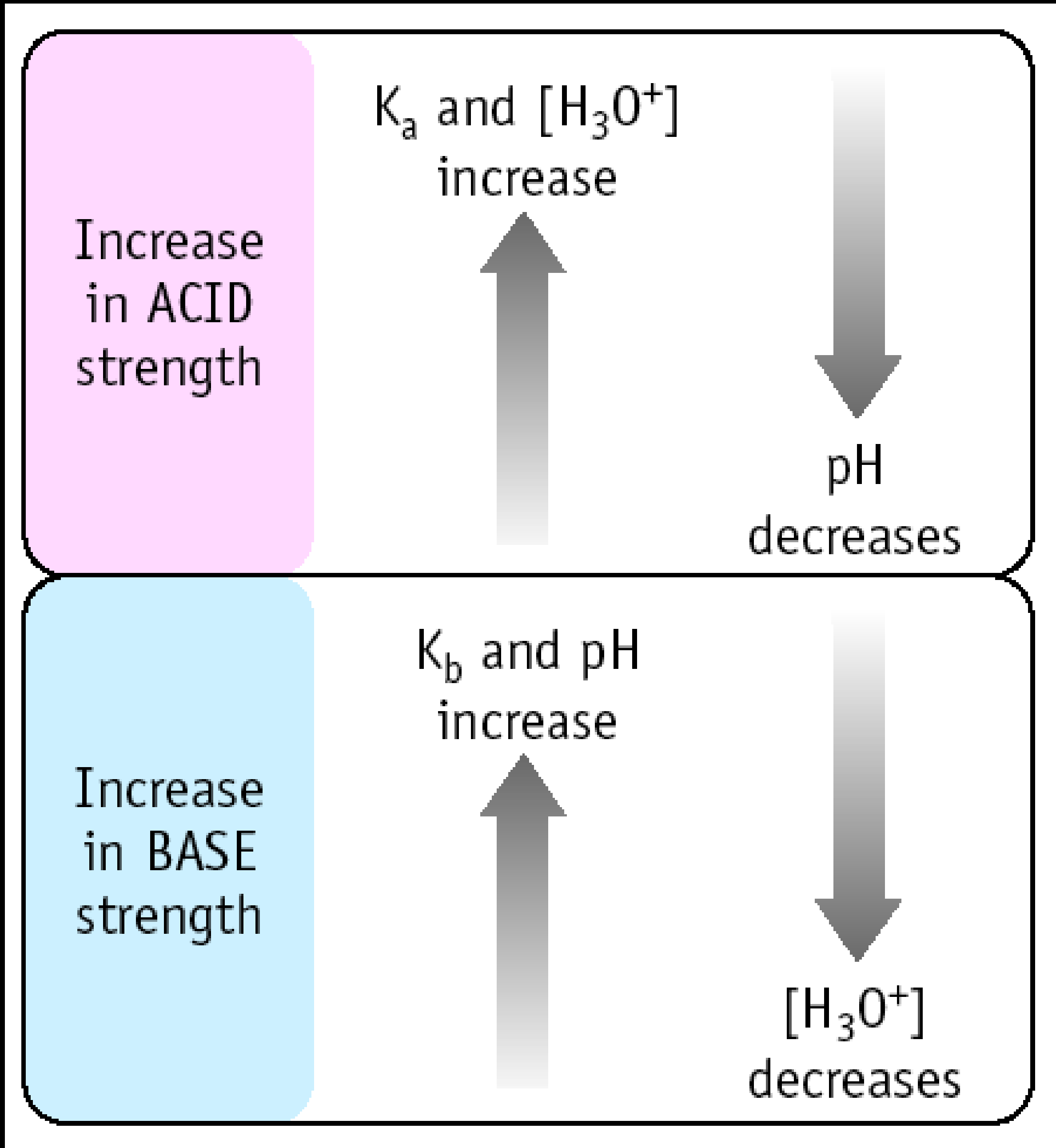
Equilibrium constants for Weak Acids

$$HA(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + A^-(aq)$$

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

Weak acid has $K_a < 1$

Leads to small $[H_3O^+]$ and a pH of 2 - 7



Relation of K_a, K_b, $[H_3O^+]$ and pH

I.C.E. Table Method

I = Initial concentration, M

C = Change concentration, M

E = Equilibrium concentration, M

RXN	HA →	H^+	A^-
I	[HA]	0	0
C	-x	+x	+x
E	[HA]-x	x	x

I.C.E. Table Method

Step 1: Write balanced equation

Step 2: Write equilibrium (K_a) expression

Step 3: Construct ICE table and fill in

Step 4: Solve for unknown concentrations using equilibrium values, use [H_3O^+] or [H^+] to find pH if asked

Practice

If the K_a of an acid, "A," is $1.5x10^{-2}$, what can you tell about its pH compared acid "B" who's K_a is $6.2x10^{-4}$?

Equilibria involving weak acids

You have 1.00 M $HC_2H_3O_2$ Calc. the equilibrium concs. of $HC_2H_3O_2$, H^+, $C_2H_3O_2^-$, and the pH. (K_a = 1.8×10^{-5})

Step 1. Write balanced equation.

$$HC_2H_3O_2 + H_2O \rightarrow H_3O^+ + C_2H_3O_2^-$$

or

$$HC_2H_3O_2 \rightarrow H^+ + C_2H_3O_2^-$$

Equilibria involving weak acids

You have 1.00 M $HC_2H_3O_2$ Calc. the equilibrium concs. of $HC_2H_3O_2$, H^+, $C_2H_3O_2^-$, and the pH. (K_a = 1.8×10^{-5})

Step 2. Write equilibrium (K_a) expression.

$$K_a = \frac{[H^+][C_2H_3O_2^-]}{[HC_2H_3O_2]}$$

Equilibria involving weak acids

You have 1.00 M $HC_2H_3O_2$ Calc. the equilibrium concs. of $HC_2H_3O_2$, H^+, $C_2H_3O_2^-$, and the pH. (K_a = 1.8×10^{-5})

Step 3. Construct ICE table and fill in.

	$[HC_2H_3O_2]$	$[H^+]$	$[C_2H_3O_2^-]$
Initial	1.00	0	0
Change	-x	+x	+x
Equilib.	1.00-x	x	x

Equilibria involving weak acids

You have 1.00 M $HC_2H_3O_2$ Calc. the equilibrium concs. of $HC_2H_3O_2$, H^+, $C_2H_3O_2^-$, and the pH. ($K_a = 1.8x10^{-5}$)

Step 4. Solve for unknown concentrations using equilibrium values, use $[H_3O^+]$ or $[H^+]$ to find pH if asked

$$K_a = \frac{[H^+][C_2H_3O_2^-]}{[HC_2H_3O_2]} = 1.8x10^{-5} = \frac{[x^2]}{[1.0-x]}$$

This is a quadratic. Solve using quadratic formula.

or you can make an approximation if x is very small!

(Rule of thumb: 10^{-4} or smaller is ok)

Equilibria involving weak acids

You have 1.00 M $HC_2H_3O_2$ Calc. the equilibrium concs. of $HC_2H_3O_2$, H^+, $C_2H_3O_2^-$, and the pH. ($K_a = 1.8 \times 10^{-5}$)

Step 4. Solve K_a expression

$$K_a = \frac{[H^+][C_2H_3O_2^-]}{[HC_2H_3O_2]}$$

$$K_a = \frac{[x][x]}{[1.0-x]}$$

First assume x is very small because K_a is so small.

$$K_a = 1.8 \times 10^{-5} = \frac{x^2}{1.00}$$

Equilibria involving weak acids

You have 1.00 M $HC_2H_3O_2$ Calc. the equilibrium concs. of $HC_2H_3O_2$, H^+, $C_2H_3O_2^-$, and the pH. ($K_a = 1.8 \times 10^{-5}$)

Step 4. Solve K_a approximate expression

$$K_a = 1.8 \times 10^{-5} = \frac{x^2}{1.00}$$

$x = [H^+] = [C_2H_3O_2^-] = 4.2 \times 10^{-3}$ M

$pH = -\log[H^+] = -\log(4.2 \times 10^{-3})$

$= 2.37$

Practice

What is the pH of a 0.020 M citric acid , $H_3C_6H_8O_7$, solution? $K_a = 7.5 \times 10^{-4}$

pH =? We need $[H^+]$ 1st $[H_3C_6H_8O_7] = 0.020M$

Weak acid, $K_a = 7.5 \times 10^{-4}$

Rxn	**$H_3C_6H_8O_7$**	**H^+**	**$H_2C_6H_8O_7^-$**
I			
C			
E			

$K_a =$ ______________

So since x = [H+] then pH must be?

Agenda

Weak Acids Continued

Standardization of NaOH and pH Apple Juice Lab

Objective:

You will know how to find the equilibrium constant of a weak acid

From Bellwork

If a 3.0M weak acid HF is used to etch glass, we need to find the concentration of [H^+] ions in the solution. Given the K_a of HF as 6.3×10^{-4}.

From Bellwork

If a 3.0M weak acid HF is used to etch glass, we need to find the concentration of [H^+] ions in the solution. Given the K_a of HF as 6.3×10^{-4}.

Now use the quadratic equation ☺

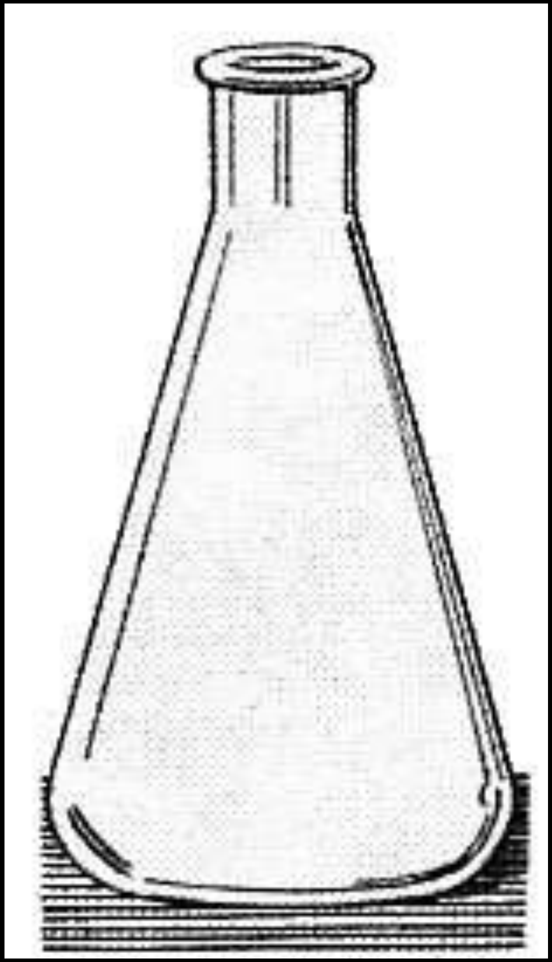
$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Practice

What is the pH of a 0.020 M Sulfurous Acid, H_2SO_3, solution? $K_a = 1.4 \times 10^{-2}$

Rxn	H_2SO_3	H^+	HSO_3^-
I			
C			
E			

K_a is >1.0×10^{-2} so we need to use quadratic to solve for "x"



Agenda

Question about K_a Expression from yesterday

k_b

Objective:

You will know how to find the equilibrium constant of a weak base

Equilibrium constants for *Weak Base*

$$B(aq) + H_2O(\ell) \rightleftharpoons BH^+(aq) + OH^-(aq)$$

$$K_b = \frac{[BH^+][OH^-]}{[B]}$$

Weak base has $K_b < 1$

Leads to small $[OH^-]$ & a pH of 12 - 7

Equilibria Involving A Weak Base

You have 0.010 M NH_3. Calc. the pH.

K_b = 1.8 E^{-5}

Step 1. Write a balanced equation

$$NH_3 + H_2O \rightarrow NH_4^+ + OH^-$$

Equilibria Involving A Weak Base

You have 0.010 M NH_3. Calc. the pH.

$$NH_3 + H_2O \rightarrow NH_4^+ + OH^-$$

$K_b = 1.8 E^{-5}$

Step 2. Define K_b expression

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]}$$

Equilibria Involving A Weak Base

You have 0.010 M NH_3. Calc. the pH.

$NH_3 + H_2O \rightarrow NH_4^+ + OH^-$

$K_b = 1.8\ E^{-5}$

Step 3. Define equilib. concs. in table

	$[NH_3]$	$[NH_4^+]$	$[OH^-]$
initial	0.010	0	0
change	-x	+x	+x
Equilib.	0.010-x	x	x

Equilibria Involving A Weak Base

You have 0.010 M NH_3. Calc. the pH.

$NH_3 + H_2O \rightarrow NH_4^+ + OH^-$

$K_b = 1.8 \times 10^{-5}$

Step 4. Solve the equilibrium expression

$$K_b = 1.8 \times 10^{-5} = \frac{[NH_4^+][OH^-]}{[NH_3]} = \frac{x^2}{0.010 - x}$$

Assume x is small, so

$x = [OH^-] = [NH_4^+] = 4.2 \times 10^{-4}$ M

and $[NH_3] = 0.010 - 4.2 \times 10^{-4} \approx 0.010$ M

The approximation is valid !

Equilibria Involving A Weak Base

You have 0.010 M NH_3. Calc. the pH.

$NH_3 + H_2O \rightarrow NH_4^+ + OH^-$

$K_b = 1.8 \times 10^{-5}$

Step 4. Calculate pH

$[OH^-] = 4.2 \times 10^{-4}$ M

so pOH = - log $[OH^-]$ = 3.37

Because pH + pOH = 14,

pH = 10.63

Now some practice ☺

The 1.0M weak base ethylamine ($C_2H_5NH_2$) has a K_b of $6.4x10^{-4}$ what is the pH of the solution (find $[OH^-]$ then convert to pH)

A 0.40 M solution of the lactate ion ($C_3H_5O_3^-$) (a weak base), has a pH of 8.728. Calculate the K_b of the lactate ion ($C_3H_5O_3^-$)

Now a hard one ☺

What is the K_a of the weak acid phenylacetic acid, $C_6H_5CH_2COOH$, if 2.1 % of the acid dissociates in a 0.12 M solution ?

Agenda

Acid base buffer Lab

Acid base Buffer lab

- Complete pre lab questions
- Caution with 1.0M HCl
- Use “HCl Droppers” for Part 2 and return when finished
- Cautions when blowing air through straw into solution 2
- All solutions down drain.

Bell Work
23.April.2015

If a 1.0L solution of HClO has a pH of 4.1, what is the original concentration of the HClO acid (K_a = 2.88×10^{-8})?

Have your pre lab out for a Stamp!

Agenda

Relationship between K_a K_b and K_w

Weak Acid Base practice

Intro To buffera

Objective:

You will feel comfortable completing weak acid base calculations and be able to describe the purpose of a buffer

Conjugate Acids of Bases

After losing a H^+, the acid species becomes the conjugate base. A base and its protonated partner also form a conjugated acid-base pair

H^+ + Base = Conjugate_acid of $Base^+$

Acid = H^+ + Conjugate_base of $Acid^-$

Conjugate Acids of Bases

H^+ + Base = Conjugate_acid of $Base^+$

Acid = H^+ + Conjugate_base of $Acid^-$

$$NH_3 + H_2O = NH_4^+ + OH^-$$

$$HAc = H^+ + Ac^-$$

Thus, NH_4^+ and NH_3 are a pair of conjugate acids and bases, as are HAc and Ac^-.

Relation Between K_a and K_b

K_a Values of Conjugate Acids of Bases

We have used K_a and K_b as the acidic and basic constants of acids and bases. Now look at the relationship between K_a of the conjugate acid and K_b of the base? Water always plays a role in the conjugation acid-base pair.

$$NH_3 + H_2O = NH_4^+ + OH^-$$

K_b K_w K_a

K_a Values of Conjugate Acids of Bases

We have used K_a and K_b as the acidic and basic constants of acids and bases. Now look at the relationship between K_a of the conjugate acid and K_b of the base? Water always plays a role in the conjugation acid-base pair.

So…

$$K_aK_b = K_w$$

Recall that is equal to 1.0×10^{-14}

K_a Values of Conjugate Acids of Bases

The K_a for HCO_3^- is 4.7×10^{-11}, what is the conjugate base and its K_b?

Solution

$HCO_3^- + H_2O \rightarrow H_3O^+ + CO_3^{2-}$

$$K_a K_b = K_w$$

The conjugate base is CO_3^{2-}.

$$K_b = (1 \times 10^{-14})/(4.7 \times 10^{-11})$$
$$= 2.1 \times 10^{-4}$$

Your Turn

The K_b for the anion of oxalic acid, $C_2O_4H^-$ is 1.8×10^{-10}. What is K_a for the oxalic acid?

$C_2O_4H_2 + H_2O \rightarrow H_3O^+ + C_2O_4H^-$

Your Turn

Calculate K_b for the acetate ion from the K_a for acetic acid of 1.8×10^{-5}

What is a Buffer

https://youtu.be/8Fdt5WnYn1k

1. What is a buffer solution?
2. A buffer solution is a mixture of…
3. A buffer does what to pH?

Closure

What are three non libratory examples of buffer solutions?

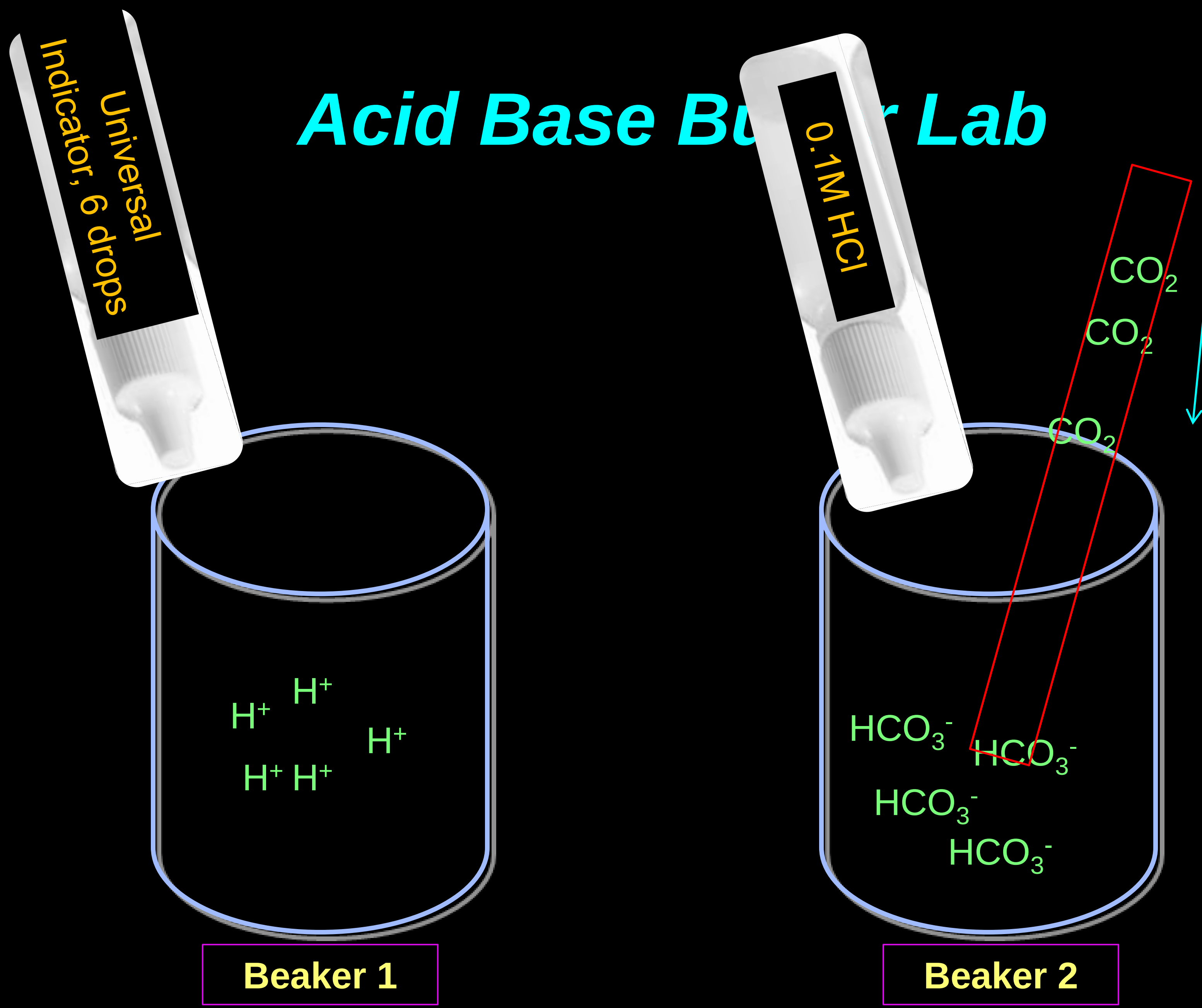
Write in you notes!

Agenda

Acid Base Buffer Lab

Objective:

You will be prepared for the exam tomorrow!


Acid Base Bu
r Lab
Universal
Indicator, 6 drops
0.1M HCl
CO_2
CO_2
CO_2
H^+
H^+
H^+
H^+ H^+
HCO_3^-
HCO_3^-
HCO_3^-
HCO_3^-
Beaker 1
Beaker 2

Types of Acid/Base Reactions: Summary

Table 17.5 • Characteristics of Acid–Base Reactions

Type	Example	Net Ionic Equation	Species Present After Equal Molar Amounts Are Mixed; pH
Strong acid + strong base	$HCl + NaOH$	$H_3O^+(aq) + OH^-(aq) \rightleftharpoons 2\,H_2O(\ell)$	Cl^-, Na^+, pH = 7
Strong acid + weak base	$HCl + NH_3$	$H_3O^+(aq) + NH_3(aq) \rightleftharpoons NH_4^+(aq) + H_2O(\ell)$	Cl^-, NH_4^+, pH < 7
Weak acid + strong base	$HCO_2H + NaOH$	$HCO_2H(aq) + OH^-(aq) \rightleftharpoons HCO_2^-(aq) + H_2O(\ell)$	HCO_2^-, Na^+, pH > 7
Weak acid + weak base	$HCO_2H + NH_3$	$HCO_2H(aq) + NH_3(aq) \rightleftharpoons HCO_2^-(aq) + NH_4^+(aq)$	HCO_2^-, NH_4^+, pH dependent on K_a and K_b of conjugate acid and base.

Types of Acid/Base Reactions: Summary

Rules for naming acids:

Acid base definitions:

Litmus paper colors:

Titration calculations:

Objective

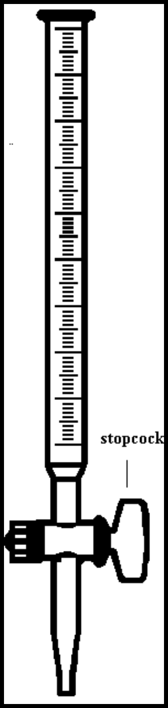
You will determine the exact concentration of NaOH you will you to titrate against apple Juice

Titration Review

	Trial 1	Trial 2	Trial 3	Trial 4
Grams of KHP				
Moles of KHP				
Final Burret Reading (ml)				
Amount of NaOH dispensed (ml)				
Initial Burret Reading (ml				
Molarity of NaOH acid				

Day 1

1. Prepare burret with ~50ml of NaOH. **Do Not return NaOH to stock bottles!**
2. Determine exact mass of KHP(~1.5E^{-3}mole, F.W. 204g/mol) being used.
3. Add DI water and 2-3 drops of phenolphthalein to solution, swirl to dissolve.
4. Titrate to find vol. NaOH needed to neutralize KHP.
5. Repeat steps 2-4 for a minimum of 3 trials.



All waste down drain

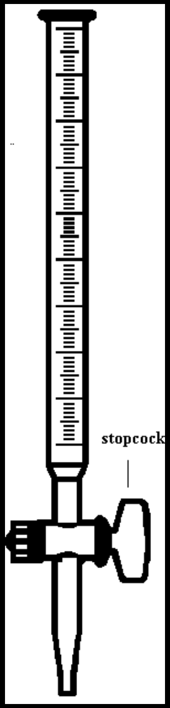
Objective

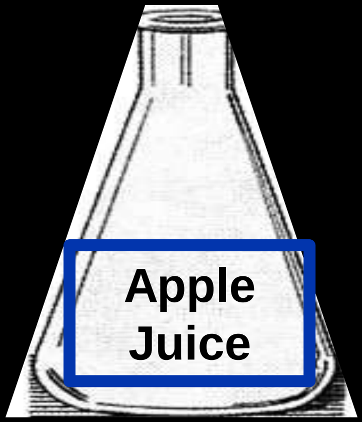
You will determine the pH apple Juice using your standardized NaOH.

Day 2

1. Prepare burret with ~50ml of NaOH. **Do Not return NaOH to stock bottles!**
2. a. Add 10mL (record exact amount) apple juice to Erlynmeyer flask.
   b. Add 15mL DI water and 2-3 drops of phenolphthalein to solution, swirl to dissolve.
4. Titrate to equivalence point.
5. Repeat steps 2-4 for a minimum of 3 trials.

Known [NaOH]





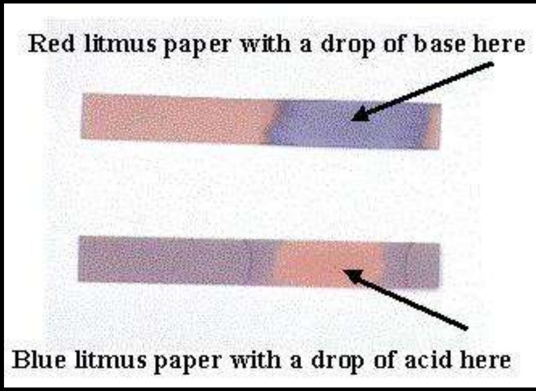
All waste down drain

Complete calculations/
post lab for both Part I
and Part II

Due tomorrow
29.April.2015

pH testing

There are several ways to test pH



- Blue litmus paper (red = acid)
- Red litmus paper (blue = basic)
- pH paper (multi-colored)
- pH meter (7 is neutral, <7 acid, >7 base)
- Universal indicator (multi-colored)
- Indicators like phenolphthalein
- Natural indicators like red cabbage, radishes

Paper testing

- Paper tests like litmus paper and pH paper
  - Place a drop of the solution from the end of the stirring rod onto a piece of the paper
  - Read and record the color change. Note what the color indicates.
  - You should only use a small portion of the paper. You can use one piece of paper for several tests.

pH paper

Behavior of Salts in Water

Table 18.8 The Behavior of Salts in Water

Salt Solution (Examples)	pH	Nature of Ions	Ion That Reacts with Water	
Neutral [NaCl, KBr, $Ba(NO_3)_2$]	7.0	Cation of strong base Anion of strong acid	None	
Acidic [NH_4Cl, NH_4NO_3, CH_3NH_3Br]	<7.0	Cation of weak base Anion of strong acid	Cation	
Acidic [$Al(NO_3)_3$, $CrCl_3$, $FeBr_3$]	<7.0	Small, highly charged cation Anion of strong acid	Cation	
Basic [CH_3COONa, KF, Na_2CO_3]	>7.0	Cation of strong base Anion of weak acid	Anion	

pH meter

- Tests the voltage of the electrolyte
- Converts the voltage to pH
- Very cheap, accurate
- Must be calibrated with a buffer solution

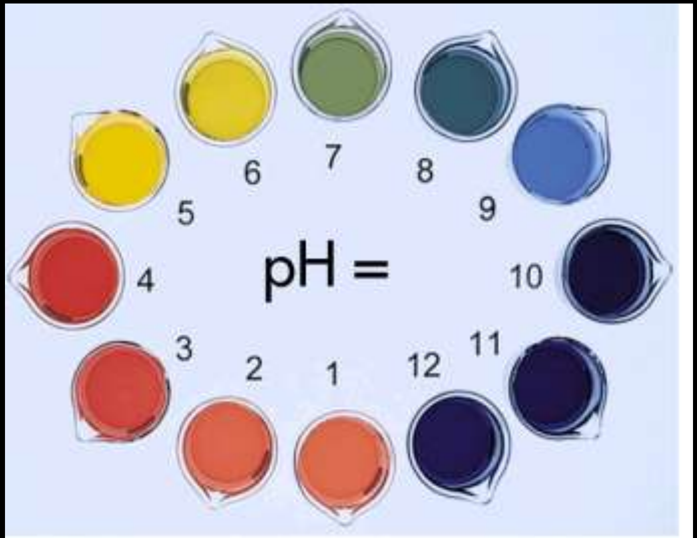
pH indicators

Indicators are dyes that can be added that will change color in the presence of an acid or base.

Some indicators only work in a specific range of pH

Once the drops are added, the sample is ruined

Some dyes are natural, like radish skin or red cabbage



Turn In

1. Weak acid weak base practice